

WHAT IS CLAIMED IS:

1. A patch antenna apparatus comprising:  
a ground plane;  
5 a dielectric substrate disposed on the ground plane;  
a patch electrode provided on a surface of the dielectric substrate opposing the ground plane;  
current-feed means connected to the patch electrode; and  
a metal frame surrounding a peripheral surface of the  
10 dielectric substrate.
  
2. The patch antenna apparatus according to claim 1,  
wherein a height dimension of the metal frame is larger than  
a thickness dimension of the dielectric substrate.  
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3. The patch antenna apparatus according to claim 1,  
wherein a plan-view shape of the metal frame is  
substantially similar to a plan-view shape of an outer shape  
of the dielectric substrate.  
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4. The patch antenna apparatus according to claim 1,  
further comprising a ground electrode disposed between the  
ground plane and the dielectric substrate.  
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5. The patch antenna apparatus according to claim 1,  
wherein the current-feed means comprises a current-feed pin  
connected to the patch electrode to permit the patch antenna  
to receive circularly-polarized waves.

6. The patch antenna apparatus according to claim 1,  
wherein a distance between the dielectric substrate and the  
metal frame are substantially uniform.

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7. The patch antenna apparatus according to claim 1,  
wherein an area of the dielectric substrate is larger than  
an area of the patch electrode.

10 8. A patch antenna apparatus comprising:  
a ground plane;  
a dielectric substrate disposed above a ground plane;  
a patch electrode provided on a surface of the  
dielectric substrate opposing the ground plane;  
15 current-feed means connected to the patch electrode; and  
at least three bar-shaped conductors, each extending in  
a thickness direction of the dielectric substrate, arranged  
in the dielectric substrate along a circumference direction  
of the dielectric substrate, the bar-shaped conductors  
20 disposed outside the patch electrode, and lower ends of the  
bar-shaped conductors connected to the ground plane.

9. The patch antenna apparatus according to claim 8,  
wherein metal pins provided in the dielectric substrate  
25 serve as the bar-shaped conductors.

10. The patch antenna apparatus according to claim 8,  
wherein through-holes provided in the dielectric substrate

serve as the bar-shaped conductors.

11. The patch antenna apparatus according to claim 8,  
further comprising a ground electrode disposed between the  
5 ground plane and the dielectric substrate.

12. The patch antenna apparatus according to claim 8,  
wherein the current-feed means comprises a current-feed pin  
connected to the patch electrode to permit the patch antenna  
10 to receive circularly-polarized waves.

13. The patch antenna apparatus according to claim 8,  
wherein an area of the dielectric substrate is larger than  
an area of the patch electrode.

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14. The patch antenna apparatus according to claim 8,  
wherein the conductors are disposed at regular intervals  
along the circumference direction.

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15. The patch antenna apparatus according to claim 8,  
wherein a plan-view shape of the dielectric substrate is  
substantially similar to a plan-view shape of the patch  
electrode.

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16. The patch antenna apparatus according to claim 15,  
wherein the plan-view shapes of the dielectric substrate and  
the patch electrode are circular.

17. The patch antenna apparatus according to claim 11, wherein the bar-shaped conductors extend through the ground electrode to the ground plane.

5 18. The patch antenna apparatus according to claim 8, wherein the bar-shaped conductors terminate at the surface of the dielectric substrate opposing the ground plane.

20. A patch antenna apparatus comprising:  
10 a ground plane;  
a dielectric substrate disposed above the ground plane;  
a patch electrode provided on a top surface of the dielectric substrate opposing the ground plane;  
current-feed means connected to the patch electrode; and  
15 at least three metal pins, each having an upright portion extending in a thickness direction of the dielectric substrate, arranged at substantially regular intervals around the dielectric substrate, a lower end of each metal pin connected to the ground plane and an upper end of the  
20 upright portion of each metal pin continues to a lateral metal member that is arranged above the dielectric substrate.

21. The patch antenna apparatus according to claim 20, wherein each metal pin is a pin member in which the upper 25 end of the upright portion is bent and the lateral metal member extends from the bent portion.

22. The patch antenna apparatus according to claim 21,

wherein the metal pin has a substantially L shape, the upper end of the upright portion being bent at a substantially right angle.

5        23. The patch antenna apparatus according to claim 21, wherein an end of the lateral metal member is disposed above the patch antenna.

10       24. The patch antenna apparatus according to claim 20, wherein a plan-view shape of the dielectric substrate is substantially similar to a plan-view shape of the patch electrode.

15       25. The patch antenna apparatus according to claim 24, wherein the plan-view shapes of the dielectric substrate and the patch electrode are circular.

20       26. The patch antenna apparatus according to claim 20, wherein the current-feed means comprises a current-feed pin connected to the patch electrode to permit the patch antenna to receive circularly-polarized waves.

25       27. The patch antenna apparatus according to claim 20, wherein a lateral distance between the dielectric substrate and each metal pin are substantially uniform.

28. The patch antenna apparatus according to claim 20, wherein an area of the dielectric substrate is larger than

an area of the patch electrode.

29. The patch antenna apparatus according to claim 20,  
further comprising a ground electrode disposed between the  
5 ground plane and the dielectric substrate.

30. A patch antenna apparatus comprising:  
a ground plane;  
a dielectric substrate disposed on the ground plane;  
10 a patch electrode provided on a surface of the  
dielectric substrate opposing the ground plane and connected  
to current-feed means; and  
redirection means for redirecting a direction of  
radiation from the patch antenna such that a direction in  
15 which the radiation is maximized is oblique to a direction  
perpendicular to the surface of the dielectric substrate.

31. The patch antenna apparatus according to claim 30,  
wherein redirection means redirects the radiation such that  
20 the maximum radiation direction is at an elevation angle of  
about 30° from a plane perpendicular to the surface of the  
dielectric substrate.

32. The patch antenna apparatus according to claim 30,  
25 wherein redirection means redirects the maximum radiation  
away from the perpendicular direction.

33. The patch antenna apparatus according to claim 30,

wherein the redirection means is laterally separated from and disposed at discrete intervals around the patch electrode.

5        34. The patch antenna apparatus according to claim 33, wherein the redirection means is laterally separated from the dielectric substrate.

10       35. The patch antenna apparatus according to claim 33, wherein the redirection means is disposed in the dielectric substrate.

15       36. The patch antenna apparatus according to claim 33, wherein the redirection means extends over the dielectric substrate.

37. The patch antenna apparatus according to claim 33, wherein the redirection means extends over the patch electrode.

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38. The patch antenna apparatus according to claim 34, wherein the redirection means extends over the dielectric substrate.

25       39. The patch antenna apparatus according to claim 34, wherein the redirection means extends over the patch electrode.

40. The patch antenna apparatus according to claim 30,  
wherein the redirection means is laterally separated from  
and disposed continuously around the patch electrode.

5 41. The patch antenna apparatus according to claim 40,  
wherein an end of the redirection means is more distal from  
the ground plane than the patch electrode.